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Trends in Hyperspectral Imaging

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Abstract: Recent advancements in hyperspectral imaging provides end users with spectral, spatial and temporal information about the data. Spectral data are captured by hyperspectral sensors. The spectral values plays vital role in various applications for detection, recognition, classification, anomaly detection etc. Since each object has its own spectral signatures, hyperspectral imaging has gained more interest in the research and has brought significant development in agriculture, military, medical diagnosis, and forensic applications. In this paper basic aspects of hyperspectral imaging such as classification, spectral unmixing, target detection and change detection are discussed.

Keywords: Hyperspectral Imaging, classification, spectral unmixing, target detection and change detection.

I. INTRODUCTION

Hyperspectral imaging is extremely used in remote sensing where exists more indiscriminate land cover areas, chemical objects to identify and recognize by spectral signatures. Every object has individual spectral values. Hyperspectral images are characterized by their spatial and also by spectral resolution. Fig 1. Shows the overall picture of hyperspectral imaging. The spatial resolution determines the geometric relationship of each image pixel with other neighbourhood pixels [1]-[3].

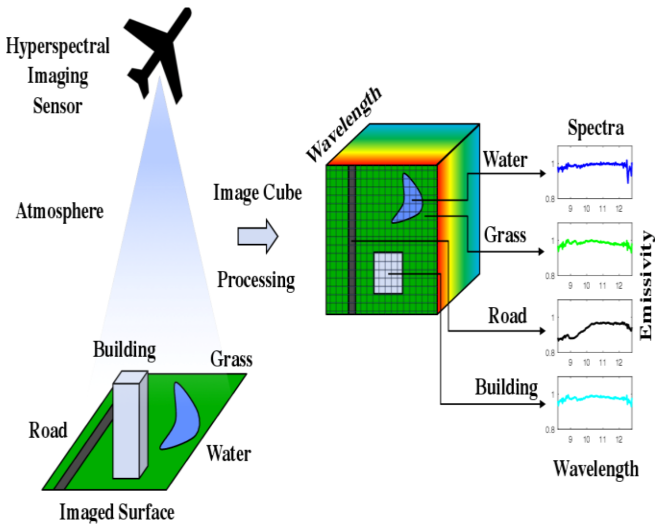

Fig 1. Hyperspectral Imaging

Spectral resolution measures the wavelength difference between the pixels. These spectral radiance is divided into spectral bands with small resolutions. These spectral values helps to extract internal details of an object while spatial values displays shape, texture, color etc [4]. By these capabilities hyperspectral imaging gained more efficiency than any other imaging technology. Hyperspectral images has more advantages than multispectral imaging including high spectral resolution; continuous spectra; and mapping and spectra. Fig 2. Shows the comparison between multispectral and hyperspectral. Due to high dimensionality of the images and limited spatial resolution, conventional methods are not suitable for those applications [2].

Subsequent section II describes the trends of hyperspectral imaging and conclusion in section III

II. CATEGORIES OF INFORMATION FROM HYPERSPECTRAL IMAGES

A. Classification

Classification is one of the major research problem especially to categorize the desired objects from thousands of bands in the hyperspectral images. Due to high dimensionality, the training sample numbers will be more that creates heaviness

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for the detector to achieve results effectively. So it is not advisable to use all the spectral bands of the image for processing. Some advances are evolved to overcome these issues such as dimensionality reduction, robust classifiers and sampling [6]

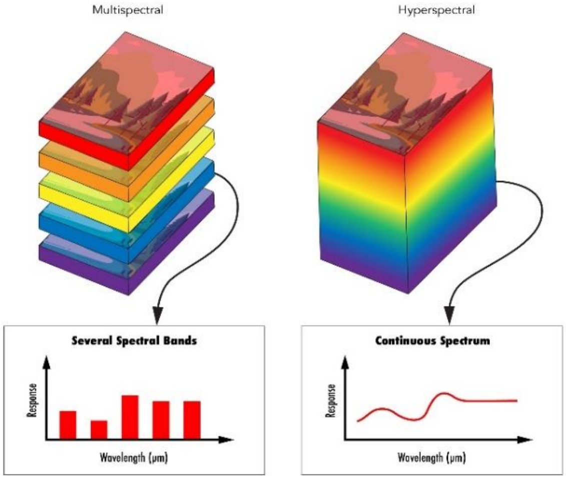

Fig 2. Comparison of Multispectral and Hyperspectral bands

a) Dimensionality reduction
Dimensionality reduction can be achieved by two ways : feature extraction and band selection .Linear discriminant analysis(LDA) is a popular method for feature extraction, many non-parametric feature extraction methods, double nearest methods are playing vital role to attain better performance [5]. Many dimensionality reduction algorithms works towards maximizing the distance between classes and minimizing the intra class distance. The best solution can be achieved by choosing the proper subset of features with less feature space.

b) Robust classifiers
Better classification can be achieved by good classifiers. A good classifier should hold the properties to decrease the time complexity, computational cost, with less weights. Many supervised and semi supervised algorithms are proposed including svm, naives bayes, ANN, ELM etc with good accuracy [7].

c) *Sampling*
Proposed algorithms are trained to understand the patterns and observations with less samples with labelled and unlabelled data. A classifier can perform well only when optimal features are extracted from feature extraction methods such as wavelet transform, gray level co-occurences [3].

B. Unmixing

Decomposing the single mixed spectrum into multiple spectra is referred as spectral unmixing. Hyperspectral unmixing is very much useful to expose the distinct materials since each image has high number of spectral bands and also the with fine spectral resolution [8]. Remote sensing applications are mostly employing this spectral unmixing. Numerous end member algorithms are proposed in recent years. The popular unmixing approaches are ICA and NMF. Fig 3. Presents the spectral unmixing.

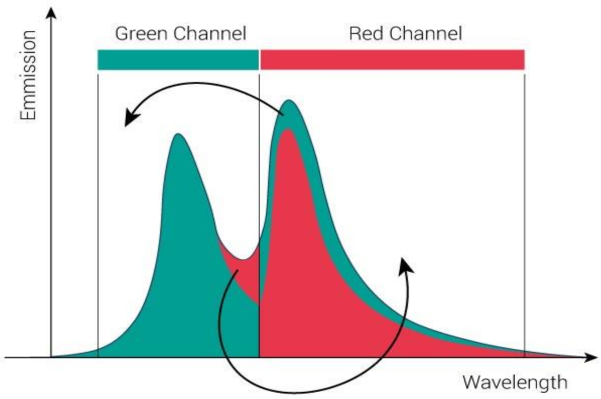

Fig 3. Spectral Unmixing

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C. Target detection

Most of the research is focused on finding the target pixels in the scene. This can be categorized into two: full pixel target detection and sub pixel target detection. Full pixel based target detection are based on the assumption that mixed spectra is present in the images. The target spectra will be separated by background spectra by known statistics. Thresholding methods can be employed here. Sometimes there will be no prior experience to extract the target pixels and such detection is called as anomaly detection [9]. The anomaly can be easily found by subtracting the background from the known targe by using distance formulae like manhattan, mahalanobis etc. Local anomaly detectors used to find the anomalies in the local window with each neighbourhood pixels whereas global detectors are applied on the entire image. In few scenarios, only a part of a pixel holds the desired data, other part is filled with one or more materials. Linear mixing model is the popular model for subpixel target detection. There is a big challenge in unstructured background known as noise. The noise can be a disturbance during capturing the images, additive data, and clumsy background. Working on hyperspectral images with more noise can produce results which is deviated from the original results, leads to wrong prediction. GLR and ACE approaches are employed for this issue. Fig 4. Depicts various targets are marked for detection [10].

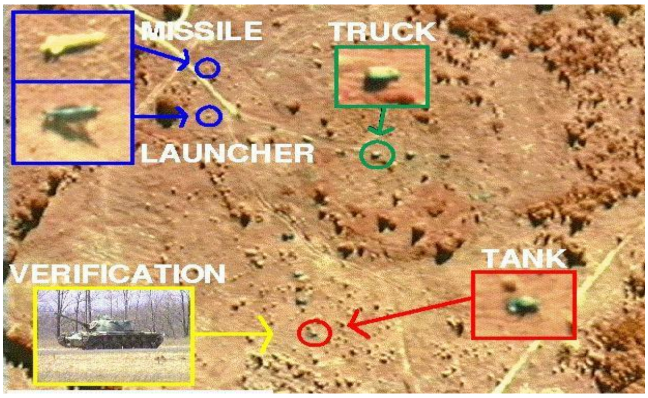

Fig 4. Target detection

D. Change detection

Change detection is one of the popular area of interest in research. With the advancement of hyperspectral sensor technology, many scholars have taken efforts to use hyperspectral images for change detection. Change can be detected in the images by calculating the difference between original image and the anomaly image. The calculation will be carried out on every pixel and band by band. Many anomaly detection algorithms are emerged to find the small changes or anomalies in the images [2]. Fig 5. Depicts anomaly change detection.

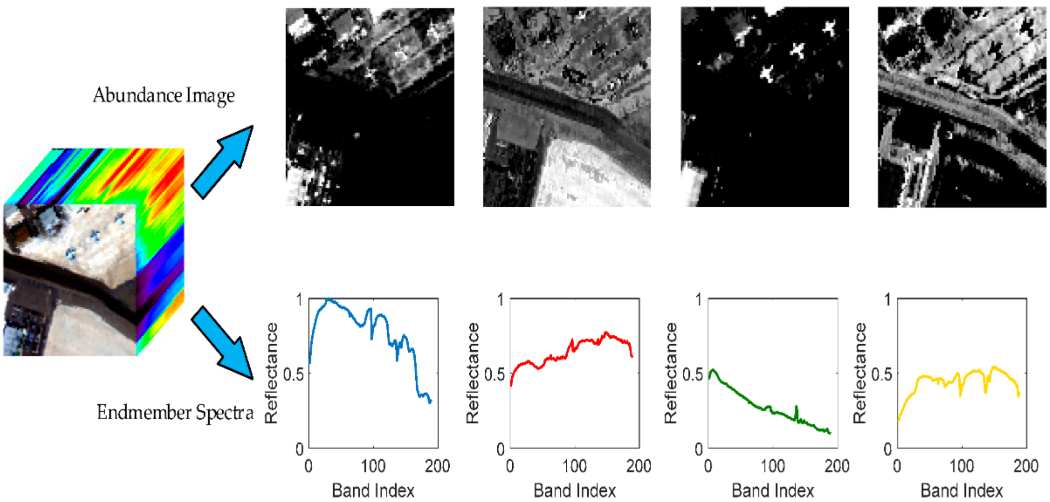

Fig 5. Anomaly change target detection

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III. CONCLUSION

Spatial information is widely used in image processing as primary input feature. Spatial information gives the relationship of each pixel with its neighbourhood pixels. There are numerous methods are there to find the spatial distance. But spectral information provides more finer details of the target. By combining both spatial and spectral information would yield better results. Hyperspectral imaging holds large volume of data and patterns behind than any other remote sensing technology. Still more robust classifiers and feature extraction algorithms are required for future research.

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